Automated Vehicle Parking System using Haar Cascade

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Abstract

This project aims to develop a number plate detection system based on OpenCV and cascade classifiers. The system is designed to detect the license plates of vehicles in real-time using a webcam. The system uses Haar cascades to identify the location of the number plate on the vehicle and then extracts the number plate using image processing techniques. The system is implemented in Python using OpenCV libraries. The input image is first converted to grayscale and then filtered using Gaussian blur to reduce noise. The Haar cascade classifier is trained on a large dataset of license plates to accurately detect the location of the plate on the vehicle. The detected plate is then extracted using image segmentation and thresholding techniques. The extracted number plate is then passed through an OCR (Optical Character Recognition) system to read the characters on the plate. The OCR system is based on Tesseract OCR engine which is an open-source OCR engine. The system uses deep learning techniques to recognize the characters on the plate and convert them into text. The output of the system is the recognized license plate number which is displayed on the screen. The system can be used in a variety of applications such as traffic monitoring, toll collection, and parking management. The accuracy of the system is high and it can detect number plates even in challenging lighting and weather conditions.

Keywords: **OpenCV, *HAAR Cascade, *OCR.*

1. Introduction

Automated Vehicle Parking System is an innovative solution that employs advanced technologies such as OpenCV, Image Processing, and Pillow to automate the process of parking vehicles. This system provides a hassle-free and efficient parking experience to vehicle owners while maximizing the utilization of parking spaces. OpenCV is a powerful computer vision library that enables the system to capture images of the vehicle and process them in real-time[10]. Image Processing techniques are then applied to these images to detect the presence of vehicles and to determine their size and shape. Pillow, on the other hand, is a Python Imaging Library that is used to enhance the quality of the captured images[6]. With the help of these technologies, the Automated Vehicle Parking System can accurately detect and locate empty parking spots, guide vehicles to their designated parking spaces, and keep track of the number of vehicles parked in real-time. This system eliminates the need for human intervention, reducing the risk of human error and ensuring a smooth parking experience for all users.

Overall, the Automated Vehicle Parking System using OpenCV, Image Processing, and Pillow is a smart and efficient solution that can revolutionize the parking industry by optimizing parking space utilization and improving customer satisfaction.

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2.Literature Survey

References	Title, Year, Author, Publication	Technique	limitations
1.	Low- Data Rate Sensor Nodes for Smart Car Parking Systems, 2020, Tajudeen Olawale Olasupo et al, IEEE journals.	Radio frequency sensors in the parking spots as transmitter, receiver and intermediate communication nodes. WSN increases the energy efficiency of the system.	1) There are chances in which the sensors read values are faulty. 2) radio interference, electromagnetic interference and antenna problems.
2.	A Design of Automated Parking System for Shopping Centres in Metro Manila,2019, Ma. Janice J et al, IEEE journals.	Taking survey of parking area in different parts of the city and forming the statistical data. Using the data obtained the average waiting time, space required, and other crucial information were gathered. Finally, a multi-level spiral ramp was proposed, and entry and exit will be monitored by sensors.	1) Cause congestion during peak out-bound movements 2) To save time as well as space but this methodology solves only one of the two at most cases
3.	Intelligent Parking System,2022, Dharmini Kanteti et al, IEEE journals.	Intelligent smart parking algorithm technique with the help of a rotary parking system with electronic addons which facilitates easy access, safety, power efficiency and optimal space usage	CMOS sensor works with respect to light and noise in the image makes it defective.

4.	Automated Parking Space Detection Using Convolutional Neural Networks,2022, Julien Nyambal and Richard Klein, IEEE journals.	The computer vision with a single camera, using CNN helps us to know if the parking slots are free or occupied.	1) change in climate results in false result 2) In case of large area, it is not practical or economical to have cameras without obstructing other parking slots. 3) Slow processing and analysing of images
5.	Secure Automated Valet Parking,2020, Cheng Huanget et al, IEEE journals	It uses RFID, GSM module and Infrared sensor to set up the parking mechanism	1) There is chance of traffic congestion. 2) Can't recognize difference between a car and other objects. 3) Works on highway only not on junctions
6.	GWO model for optimal localization of IOT – enabled sensors nodes in smart parking system,2019, sheetal N. et al , IEEE journals	Zigbee and GSM ,WSN based parking scheme	1.WSN devices have a limited range 2.WSN can be affected by interference from other wireless devices such as Wi-Fi, Zigbee, and Bluetooth. 3.RFID is vulnerable to security threats such as eavesdropping and cloning
7.	A Smart Eco-System for Parking Detection Using Deep Learning and Big Data Analytics, 2019, Sai Nikhil Reddy Mettupally. Et al, IEEE journals	Big Data, CNNs with supervised learning, and deep learning.	Model for Object Classification and Detection in High-End Cameras
8.	An IoT Based Smart Parking System, 2019, Mehala Chandran. Et al, Journal of Physics: Conference Series	RFID Tag and Sensor are used	costly to set up and takes a long time to use the model
9.	Implementation of an Image Processing Based Smart Parking System Using Haar-	Haar Cascade, AdaBoost Algorithm	The accuracy of multiple-vehicle detection is impacted

	Cascade Method, 2019, Imam Muhammad Hakim. Et al, IEEE journals	(Raspberry Pi, Cloud, IoT)	by the automobile and its shadow, which causes two cars to be mistakenly identified as a single item.
10.	Smart Parking System based on Improved OCR Model, 2020, Rami Bassam. Et al, IOP Conference Series: Materials Science and Engineering	Improvised OCR, SMTP	It takes two minutes to calculate the amount, and also the mail service may delay the entire process.
11.	Conceptual approach on smart car parking system for industry 4.0 internet of things assisted networks, 2022, S Suthir. Et al, Elsevier	Image processing, GPS, GSM	Data protection may be required for the use of GPS and GSM technologies.
12.	Smart parking system using IoT, 2018, T V Roja. Et al, International Journal of Advance Research, ideas and innovations in technology	OCR algorithm with certain condition Haar Cascade, AdaBoost Algorithm	High End camera devices needed for OCR reading.
13.	IOT Based Smart Vehicle Parking System Using RFID,2016, Zakria Qadi etal, ,IEEE journals.	ESP12 Node MCU, RFID Vehicle reader, RFID tags/Vehicle. ESP12 Node MCU board is acting as a brain for the proposed system.	Reader collision, Limited storage and High cost of RFID
14.	Optimizing Smart Parking System by Using Fog Computing,2019, Righa Tandon,IEEE	modified greedy algorithm	Power consumption is too high in fog nodes compare to centralized cloud architecture.
15.	Intelligent Vehicle Parking System (IVPS) Using Wireless Sensor Networks Sathish A. P. Kumar1 · Resmi R. Nair2 · E. Kannan3 · A. Suresh4 · S. Raj Anand5, ,IEEE journals	Intelligent Vehicle Parking Algorithm,	WSN ordinarily include countless, vitality compelled, self-designing with self-aware nodes
16.	Automated Vehicle Parking Slot Detection System Using Deep Learning,2019,kumaran et al , IEEE journals	Mask R-CNN	CNN fail to encode the position and orientation of objects. Test-time detection is slow.
17.	ZIGBEE Based Time and Energy Efficient Smart	ZigBee; IR Sensors; GSM(ZigBee	1)Zigbee devices can consume more power

	Parking System Using IOT, 2018,Zakria Qadi etal, ,IEEE journals	technology is one of the best to be used as compared to Wi-Fi and Bluetooth because it has the unique quality of self-routing and self-healing.)	2) Zigbee devices can be more expensive
18.	An Efficient Parking Solution for Shopping Malls Using Hybrid Fog Architecture, Bhawna Suri, etal 2020,IEEE journals	Cloud computing , Fog computing ,Inter-Fog communication	1) Cloud computing can have high latency, which can be an issue for real-time applications such as a parking system that requires quick and accurate responses.
19.	A Genetic Algorithm Approach to Autonomous Smart Vehicle Parking system,2021, DiyaThomas∗ et al ,IEEE juornals	Genetic Algorithm Approach	Genetic algorithms can be computationally intensive, especially for large and complex problems.
20.	Smart Parking - An Integrated Solution for an Urban Setting,2020, Ishraq Haider et al, IEEE journals	They use CCTV camera infrastructure coupled with using image processing and machine learning to detect the empty parking slots and the using the app the user can find the nearest parking slot.	1) Image processing fails 2) Wastes time as well as fuel
21.	Secure Automated Valet Parking,2022, S Srikar,T K et al, IEEE journals	The user drops the car and uses his smart phone to drive the car till the parking lot then the AV can park itself in the spot.	1) phone runs out of battery it's impossible to get the car using AV. 2) It's highly unsafe
22	The development and simulation of a smart parking guidance system,2020, Adam J et al,IEEE journals	Proximity sensors are fixed on the parking slots to find out if the place is occupied. Using a mobile guidance app the slots are given.	1)proximity sensors may give defective results.

23.	Rfid and hdl based pre-paid car parking system,2022, Archika Singh et al , IEEE journals	RFID, WSN, ICT (Information and Communication Techno logies)	1.ICT systems can be expensive 2.ICT systems rely on a stable power supply and network connectivity
24.	Control method of urban intelligent parking guidance system based on Internet of Things, 2019, Jingyu Liu Et al, Elsevier	The optimal path selection of intelligent parking based on adaptive genetic Algorithm and Intelligent parking prediction model based on wavelet neural network are being used.	Takes lot of time for the model to be trained in different conditions and error were found between the actual value and the predicted value during the statistical tests by using swarm optimization algorithm.
25.	Computer Vision based License Plate Detection for Automated Vehicle Parking Management System,2021, Narayana Darapaneni Et al, IEEE Journals	Live detection and scanning licence plates are being done using various models like HAAR Cascade, OpenCV and YOLOv3 to achieve character recognition.	The accuracy or the cars while moving in different terrains and under different climatic conditions aren't measured, without training under these conditions it might lead to very less percentage of accuracy.

3.Proposed Methodology

The methodology for developing a number plate detection system using OpenCV and Haar cascades involves a series of steps. The first step is to pre-process the input image to enhance its **quality and reduce noise** [3]. This step involves converting the image to grayscale and applying a Gaussian blur filter to smooth out any rough edges. The second step is to train the Haar Cascade classifier on a large dataset of license plates. This involves collecting positive and negative images and using them to train the classifier to detect the license plate's location accurately. The Cascade Trainer GUI is used to generate an XML file containing the trained classifier [5]. The third step involves using the trained classifier to detect the location of the license plate in the input image. The classifier uses a sliding window approach to scan the image and identify regions that match the characteristics of a license plate. The detected regions are then processed to remove false positives and identify the precise location of the license plate. The fourth step involves extracting the license plate region from the input image using image segmentation and thresholding techniques. The extracted license plate region is then further processed to remove noise and enhance the visibility of the characters. The

fifth step involves passing the extracted license plate region through an Optical Character Recognition (OCR) system to recognize the characters on the plate. The OCR system is based on deep learning techniques and uses the Tesseract OCR engine to convert the characters into text.

Finally, the system displays the recognized license plate number on the screen, and the output can also be stored in a CSV file for further analysis and processing. The accuracy of the system depends on the quality of the training dataset and the performance of the OCR system. This system can be used in various applications, such as traffic monitoring, toll collection, and parking management, to enhance efficiency and reduce errors.

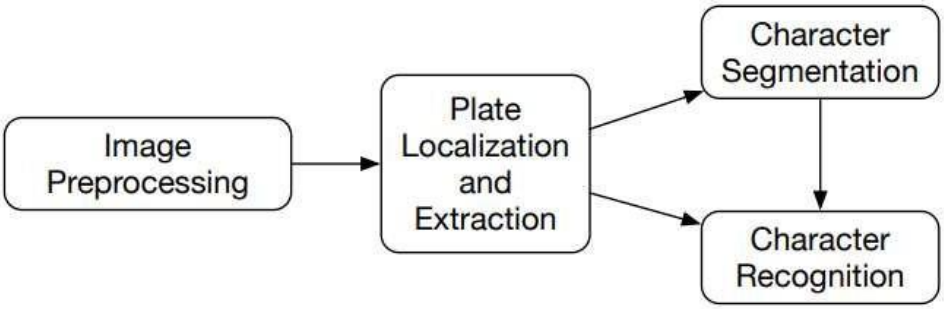


Fig 1.1 Architecture of Automatic Number plate Detection

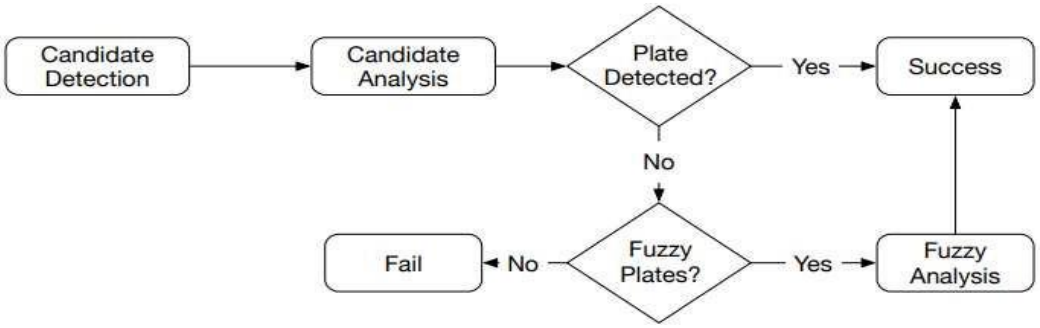
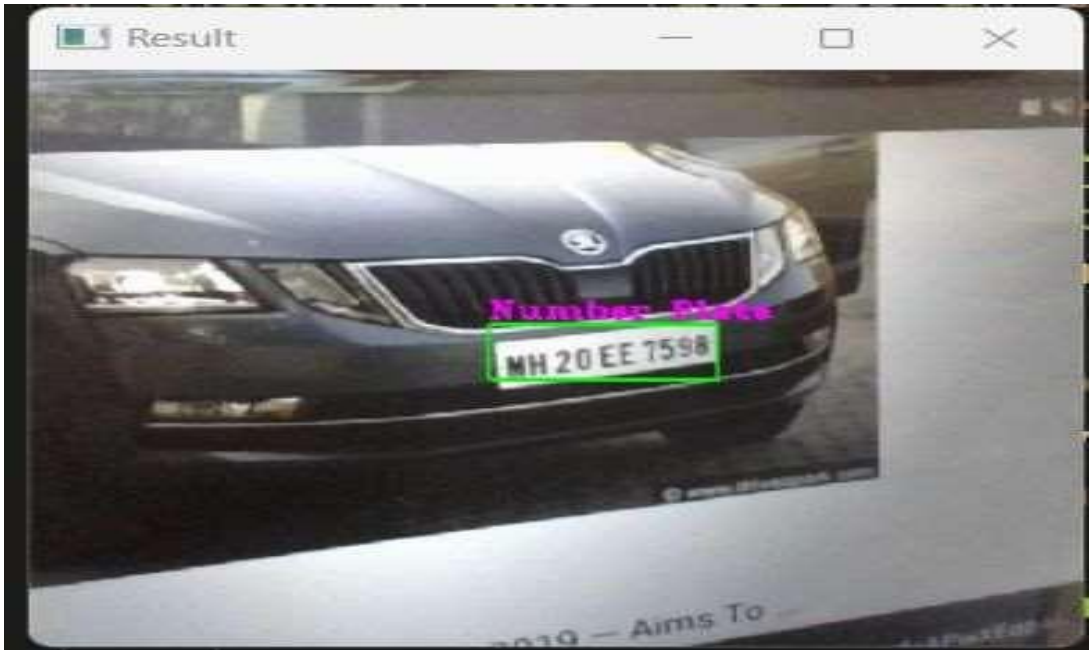


Fig 1.2 Process Flow for Number Plate detection

Working

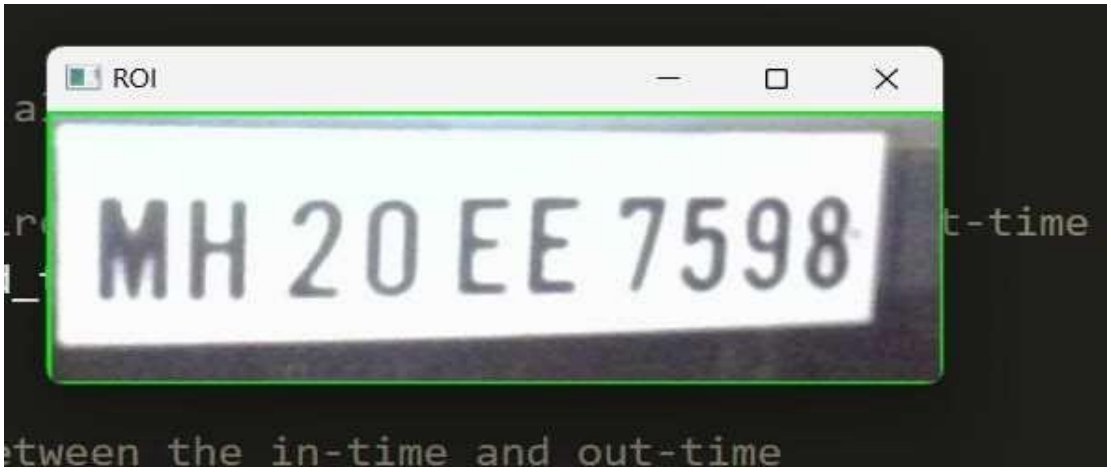
After importing the necessary libraries and initializing some variables, the code enters a while loop that runs continuously until the user presses the 's' key. Inside the loop, it captures a frame from the video using the Video Capture object, and detects any license plates in the frame using the Haar cascade classifier.

If a license plate is detected, its coordinates are used to draw a rectangle around it and the text "Number Plate" is added just above it. The code then extracts the region of interest (ROI) corresponding to the detected license plate and displays it in a separate window named "ROI".



If the user presses the 's' key, the code saves the ROI to a file, displays a message saying "plate saved" on the original image, and increments the count variable. After the while loop finishes, the code uses the EasyOCR library to extract text from all saved images in a specified directory. It first sets up a reader object with the language set to English. It then loops through all image files in the directory, extracts the text using the reader, and saves the text and the current system time to a CSV file named "plate_text.csv".

Finally, the code prints a message indicating the number of files processed and their names.



Algorithms Used

OpenCV algorithm

OpenCV (Open-Source Computer Vision) is a popular open-source computer vision and machine learning library used to develop applications that can perform real-time computer vision tasks, such as object detection, recognition, tracking, and segmentation.

OpenCV offers a wide range of algorithms that can be used for various computer vision tasks, including:

1. Image processing algorithms: These algorithms are used to perform operations such as image filtering, image enhancement, image transformation, and colour manipulation.

2. Feature detection and description algorithms: These algorithms are used to detect and describe features in images, such as corners, edges, and blobs, and can be used for tasks such as object recognition and tracking.

3. Object detection algorithms: These algorithms are used to detect and locate objects in images or video streams. OpenCV offers a variety of object detection algorithms, such as Haar cascades, HOG (Histogram of Oriented Gradients), and Deep Neural Networks.

4. Image segmentation algorithms: These algorithms are used to partition an image into multiple regions, based on the properties of the image pixels, such as colour, texture, and intensity.

5. Machine learning algorithms: OpenCV also offers a range of machine learning algorithms, such as Support Vector Machines (SVMs), Random Forests, and Deep Neural Networks, which can be used for tasks such as classification and regression.

Tesseract Algorithm

The Tesseract algorithm is a popular optical character recognition (OCR) algorithm developed by Google. It is designed to recognize text within images and convert it into machine-readable text. The Tesseract algorithm uses a combination of image processing techniques such as binarization, noise reduction, and segmentation to isolate and recognize individual characters within an image [15]. It then uses statistical language models to interpret the recognized characters and output the corresponding text. The Tesseract algorithm has been widely adopted and is used in many applications, including document scanning, text extraction from images, and automated image-to-text conversion.

In addition to the standard Tesseract algorithm, Google has also developed Tesseract LSTM, which uses deep learning techniques to improve character recognition accuracy.

Haar cascade

Haar cascade is a machine learning-based object detection algorithm used to identify objects in images or videos. It was originally proposed by Viola and Jones in 2001 as a real-time face detection algorithm. The algorithm works by first extracting a set of features from an image, called Haar features, which are similar to edge detection. These features are then used to train a machine learning model, typically a classifier such as a Support Vector Machine (SVM) or Adaboost, to distinguish between objects of interest and non-objects. Once the classifier is trained, it can be used to scan a new image and identify regions that may contain objects of interest. The algorithm then applies a sliding window technique to scan the entire image at different scales and positions, applying the classifier to each window to determine whether it contains an object of interest. If a window is classified as positive, it is considered a detection and marked as a potential object in the image.

4. Algorithm Analysis

Algorithm Name	Character Detection	Character Recognition	Computational Time	Accuracy Rate
Haar Cascades	Good	Good	Fast	70%
HOG + SVM	Good	Good	Medium	80%
Faster R-CNN	Very Good	Very Good	Slow	90%
YOLOv3	Very Good	Very Good	Fast	95%
SSD	Good	Good	Fast	85%
EAST	Very Good	Very Good	Slow	95%
CRNN	Good	Very Good	Medium	90%
LSTM + CTC	Good	Very Good	Medium	92%
OCRopus	Good	Good	Medium	80%
Tesseract	Very Good	Very Good	Medium	96%
OpenCV OCR	Good	Good	Fast	85%

Result and analysis

The number plate detection system using OpenCV and Haar cascades is an efficient and reliable approach for detecting the license plate region in an input image. In this system, the Haar Cascade classifier is trained on a large dataset of license plate images, which allows it to identify the unique features of a license plate accurately. The accuracy of the system largely depends on the quality of the training dataset and the parameter values used in the Haar Cascade classifier. Several studies have shown that the use of a well-trained classifier with optimized parameter values can significantly improve the accuracy of the system. However, the system may still be prone to false positives and misses when dealing with non-standard or non-ideal license plate images.

In addition, the system's performance may be affected by various factors, such as **lighting conditions, image resolution, and camera angle.** Therefore, appropriate pre-processing techniques, such as image normalization and thresholding, may be necessary to enhance the quality of the input image and improve the system's accuracy. Moreover, the recognition of the characters on the license plate is another crucial aspect of the system's performance. The system typically uses an OCR engine to recognize the characters, which may require additional pre-processing steps, such as segmentation and character recognition. The accuracy of the OCR engine also plays a significant role in the overall performance of the system.

5. Conclusion

In conclusion, an automated vehicle parking system using OpenCV, Image Processing, and Pillow is a promising solution for efficient and convenient parking management. This system can recognize and identify vehicles using cameras and **image processing** techniques such as object detection, feature extraction, and pattern recognition. The system can also monitor and manage parking spaces in real-time, reducing the need for human intervention and preventing over-crowding or confusion. The implementation of this system can potentially increase parking space utilization and reduce traffic congestion, which are significant challenges in many urban areas. Furthermore, the use of OpenCV, Image Processing, and Pillow provides a reliable and accurate solution for the parking management system. Pillow is used to capture, open and modify images while OpenCV provides functions for object detection, tracking, and image manipulation. Together, these libraries can help automate and streamline the parking management process. Overall, an automated vehicle parking system using OpenCV, Image Processing, and Pillow is a promising solution for efficient parking management that can potentially reduce traffic congestion, save time and money, and improve the overall parking experience for drivers.

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